
AMS-02 - ACOP

Critical Design Review

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ER Integ. Agreement(EIA) requests (1/2)

- ACOP is considered a portion of the AMS-02 payload and it resides within the US-Lab pressurized volume of an ISS.
- ACOP Mission duration is about 3/4 Years; it will cover the AMS-02 Mission and it will operate with AMS-02 (3 years operating). ACOP on orbit transportation is planned about 6 Months before of AMS-02.
- ACOP provides capability for data storage, monitoring and linkage to the ISS for command and downlink.
- The ACOP is delivered and checked out before the arrival of the external AMS-02 un-pressurized payload.
- ACOP will be delivered to the ISS by the Space Shuttle and it will be installed into an Express Rack. The primary scope of ACOP is to put available a large memory space to store a huge AMS Experiment temporary data before of Ku band downloading.
- The ACOP on orbit transportation is planned inside a STS Mid Deck Locker as well as the ORU parts on orbit transportation, by using Soft bags

EIA request (2/2)

- For ACOP is required to be categorized as a “Standard Express Rack”. At present exist deviations from the Standard Express Rack Concept.
 - HRDL communication lines (Standard ER should exploit standard ER I/F's only)
 - ORU parts stowage container (Standard ER should not have stowage item external to the payload)
- ACOP will be accommodated in a MDL/ISS locker inside a Standard 8/2 Express Rack
- ACOP will utilize 1 soft bag for ORU part stowage purpose.

EIA Resources Requirement (1/

- On-Orbit Volume (cubic meters) - The volume required on-orbit for internal accommodations, including experiment and stowage volume. (0.163 m³)
- Up Mass (kilograms per year) - The total payload and resupply mass to be launched in support of payload operations, including payload structure, special flight support equipment and logistics carriers, as appropriate. (32.7Kg/year)
- Down Mass (kilograms per year) - The total payload and resupply mass to be returned in support of payload operations, including payload structure, special flight support equipment and logistics carriers, as appropriate. (32.7Kg/year)

EIA Resources Requirements

- Up Volume (cubic meters, per year) - The total payload and resupply volume to be launched in support of payload operations, including payload structure, special flight support equipment and logistics carriers, as appropriate. (0.9m³/year)
- Down Volume (cubic meters, per year) - The total payload and resupply volume to be returned in support of payload operations, including payload structure, special flight support equipment and logistics carriers, as appropriate. (0.9m³/year)

EIA Resources Requirements

- Energy (kilowatt hours) - Total energy required per year for payload operations. (1750Kwatt hour/year). This means 200Watt continuously power.
- Crew Time (hours per year) - Total crew time required per year for payload operations. This includes nominal operations and maintenance operations activities. (20hours /year)
- Communications Downlink (terabits per year) - Total communications downlink required per year for payload operations. 70 terabits/year (TBR)
- Communications Uplink (Megabits per year) - Total communications uplink required per year for payload operations. 8 Mbits/year (TBR)

EIA Resource Requirements

- A special resource is required for ACOP that usually is not available for a standard Express Rack payload. ACOP requires two transmit and one receive High Rate Data Link channels in order to get the AMS Experiment telemetry data and to download them on ground.
- Two HRDL J7 connectors on ISPRs UIP should be available close to the Express Rack (TBD) where ACOP has been installed.
- To get the HRDL channels, optical fiber cables should be installed inside the laboratory from ACOP to the available J7 connectors, following a defined path agreed between EPIM and AMS-02 Program.

EIA Resource Requirements

- The access to the HRDL is required in order to record AMS telemetry data that are downloaded with 2 Mbits average of bit rate and about 40Mbits (TBC) of peak rate. Inside the ISS, the HRDL channel only assures this performances in term of bit rate.
- Full time and Full duplex connectivity between AMS-02 and ACOP is required.
- One TX and one RX HRDL channel are exploited for AMS-02 Full duplex connectivity while one TX HRDL channel is exploited to download on Ground AMS-02 Telemetry Data.

EIA Resources Requirements

- Utilize one (1) International Standard Payload Rack (ISPR) ISS/MDL locker for the planned 4-years of payload mission life
- Utilize two (2) MLEs for subrack payload equipment transport to and from the ISS pressurized volume for AMS-02 pressurized payload assembly
- Utilize the Express Rack Payload Computer to provide MMI I/F's to the Crew.
- On-orbit payload stowage required for exchanging of payload media (e.g., removable hard drives) in addition to the one (1) ISS locker utilized as the AMS-02 Crew Operations Post. Passive stowage for 20 exchangeable payload computer media components. 1 MDL Equivalent volume required in addition to the ISS locker (TBR)

EIA Resources Requirements

- Earlier ISS flight (AMS-02 L-3 to L-6 months) required to stage/install the ACOP assembly in ISS locker and install/initialize/checkout in the pressurized volume before AMS-02 truss-attached payload assembly portion is integrated and berthed on station. Passive stowage until arrival on station of the AMS-02 truss-attached payload assembly.

EIA interface requirements

• Module level	Compatible (Yes/No)
– U.S. Lab	YES
– Japanese Experiment Module (JEM)	(TBD)
– Columbus Orbital Facility (COF)	(TBD)
– Centrifuge Accommodations Module (CAM)	(TBD)

EIA interface requirements

- The following I/F's are required in the EIA
- Interfaces Required (Yes/No)
 - Power
 - 200 W (24x7) YES
 - Data
 - RS 422 YES
 - Ethernet YES
 - PD Developed Software on ERLaptop Computer YES
 - 5 Vdc discrete NO
 - 2 TX HRDL and 1 RX HRDL (Non Standard) YES
 - Cooling
 - EXPRESS Rack Avionics Air Assembly (AAA) Air Sys YES

Interface Control Document Applicable 1/2

- The applicable ICD will be the following
 - SSP52000-IDD-ERP for
 - Physical & Mechanical I/F's
 - Structural I/F's
 - Thermal I/F's
 - Power I/F's
 - Electrical I/F's
 - Control Data I/F's
 - Software I/F's
 - Human Factor I/F's
 - Safety (still to be provided)

Interface Control Document Applicable 2/2

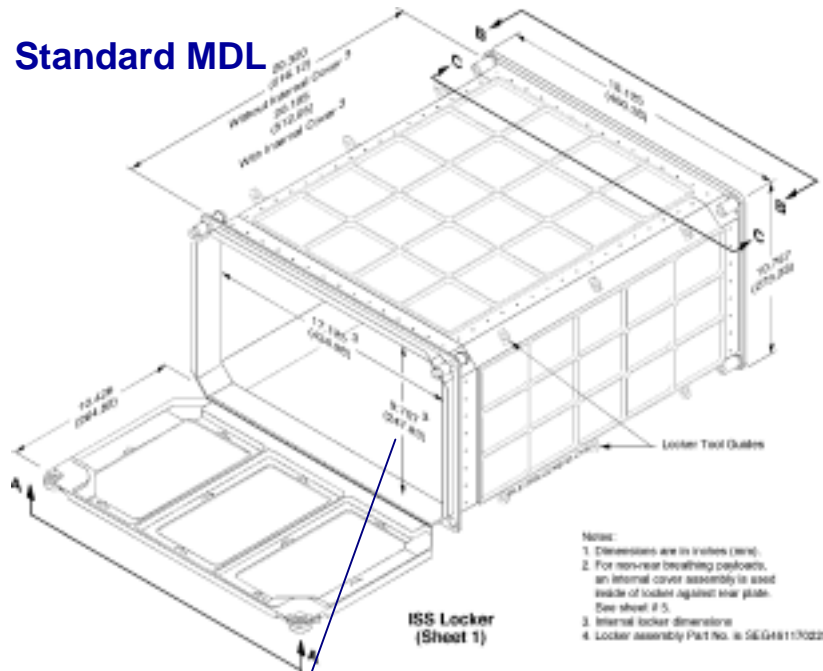
- SSP 50184 Physical Media, Physical Signaling & link-level Protocol Specification for ensuring Interoperability of High Rate Data Link Stations on the International Space Program
- SSP 52050 S/W Interface Control Document for ISPR (HRDL section only)
- This last two document are inserted in order to cover non-standard HRDL interfaces.

Physical & Mechanical I/F's requirements

- The Physical & Mechanical I/F's will be compliant to the SSP52000-IDD-ERP section 3.3 concerning the standard modular MDL/ISS locker sections.
 - The deviation from the standard concerns the front panel configuration. A custom front panel will be manufactured
 - ORU parts will be stowed in one (TBC) soft bag
- The Mass Budget will be provide for the CDR. At present estimated value is about 26Kg (for ACOP only ORU parts excluded).

Mechanical Design (MDL)

Standard MDL

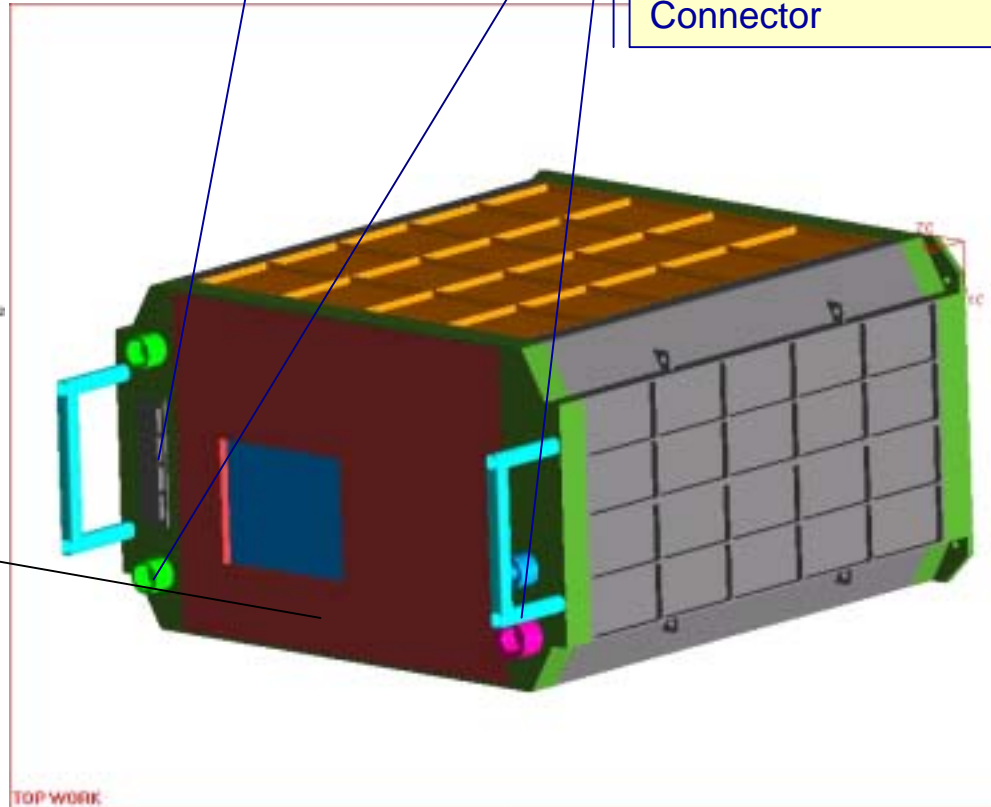


ISS Locker Size

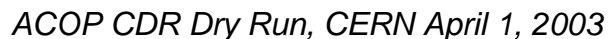
- Width 434,98mm
- Height 264,82mm
- Length 516,12mm

Front panel button

POWER(28v) and
DATA (HRDL
(2tx,1rx), 1 Rs422,
2 Ethernet)
Connector



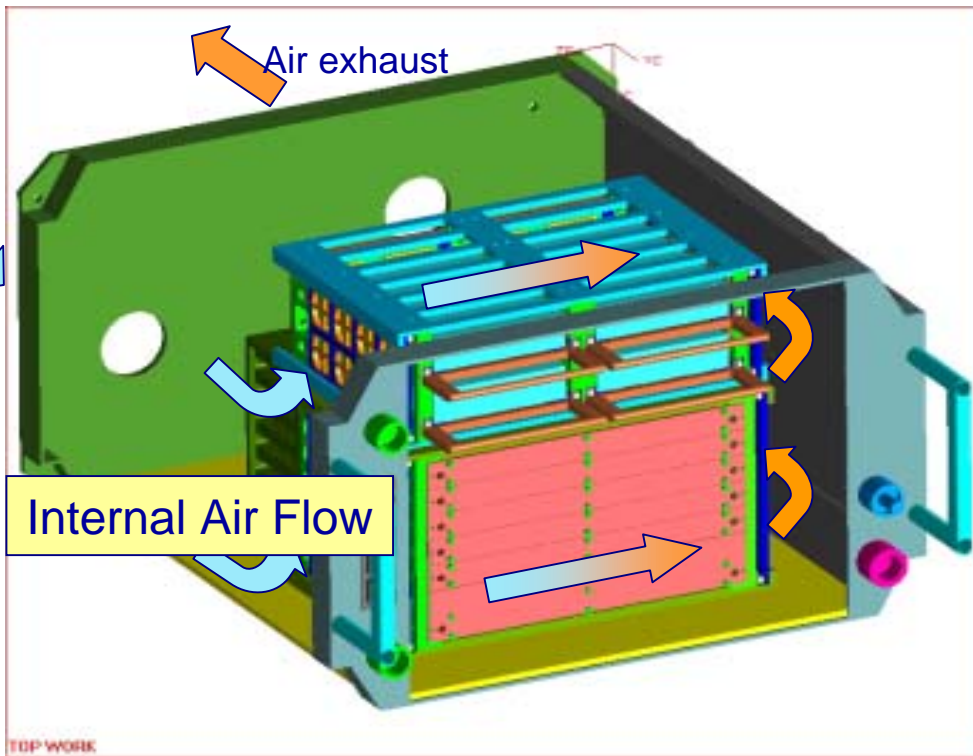
Standard ISS soft bag



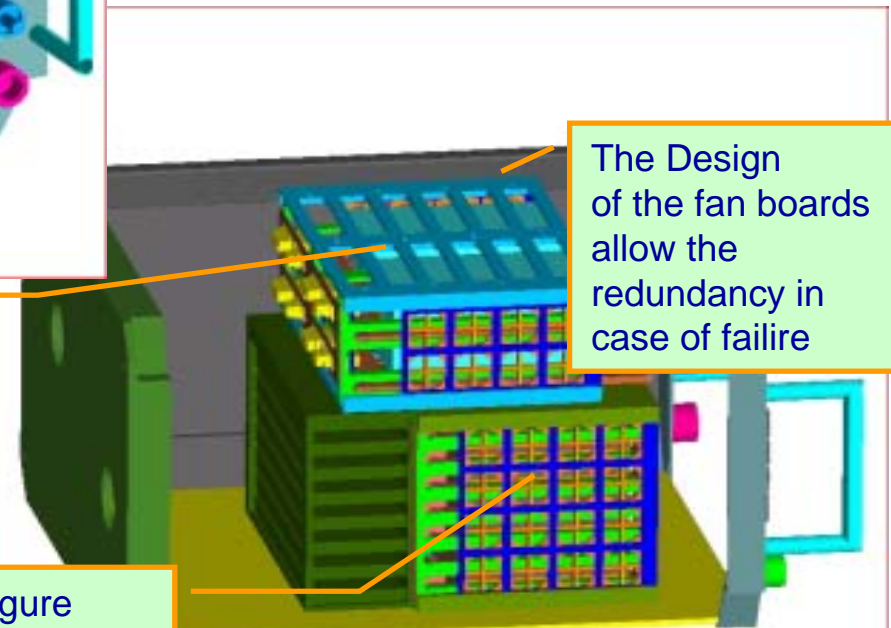
Thermal Cooling requirements

- Thermal Cooling design will be compliant to the SSP52000-IDD-ERP document section 5
- Ducted Air and Cooling via Avionics Air Assembly ($\leq 200\text{Watt}$) will be required for ACOP.
- ACOP will provide for internal air circulation 12 fans CFM (TBD). Fans redundancy will be provided. Noise control is provided by fan speed controls.
- The Front Panel surface temperature which is exposed to the Crew Members bare skin contact shall be maintained between -18°C and 49°C (as define in the IDD document)

Thermal Cooling Design



Thermal Analysis will be provide



The H/D's and Boards racks structure is opened in order to allow and maximiza the air flow

flexibility to configure the fan boards positioning the fan in the structure

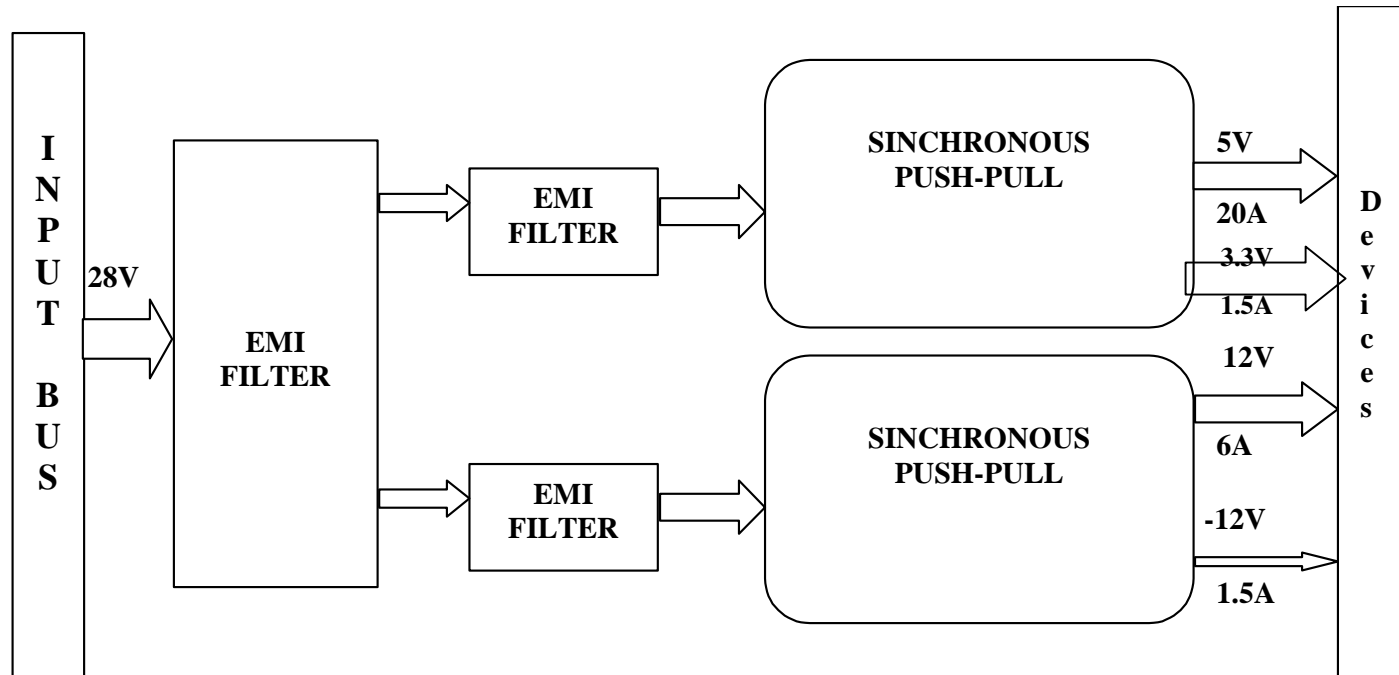
The Design of the fan boards allow the redundancy in case of failure

Power/Electrical I/F's requirements

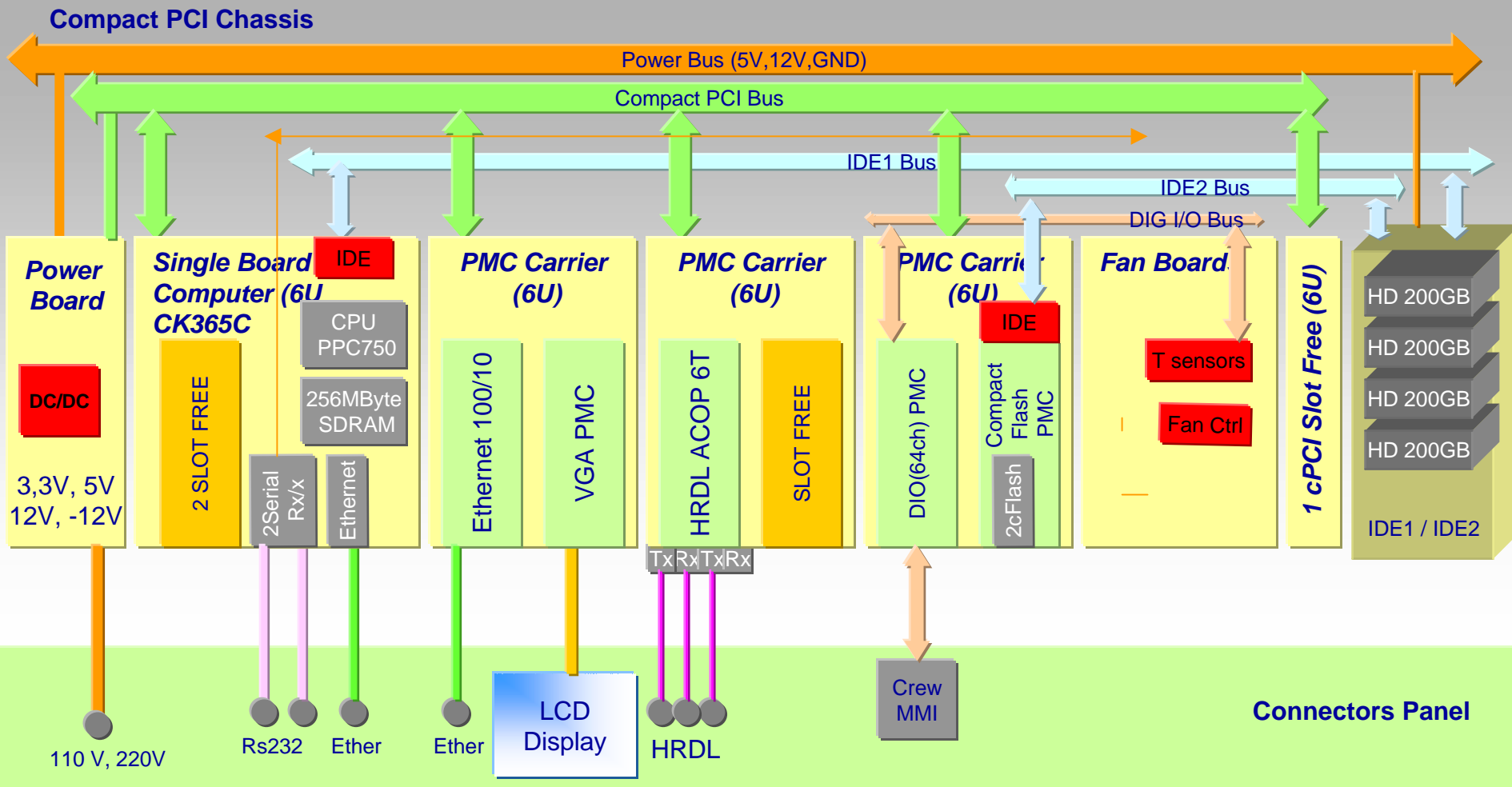
- The Power requirement will be compliant to the SSP52000-IDD-ERP document section 6
- The ACOP will not be powered during the NTS on-orbit transportation.
- The ACOP will be powered by means of the connectors on the ER upper or lower connector panel. Wire will be provided to link ACOP front panel power connector to the ER connector panel. Electrical connector will meet the SSP-52000-IDD-ERP section 6.6
- ACOP will provide overload protection devices (fuses and circuit breaker) for the power input line.
- ACOP power request is $\leq 200\text{Watt}$ (TBC). The power budget will be provided for the CDR. At present the Estimated value is about 110W average.
- ACOP input power line will be isolated from the structure by at least 1 MegaOhm with a parallel capacitance of $\leq 10\text{MicroF}$ measured at ACOP interface connector contact

Power Board schematic

Name	V _{out} (V)	I _{out} (A)	P _{out} (W)
V1	5	20	100
V2	12	6	72
V3 option	-12	1	18
V4	3.3	1.5	5W



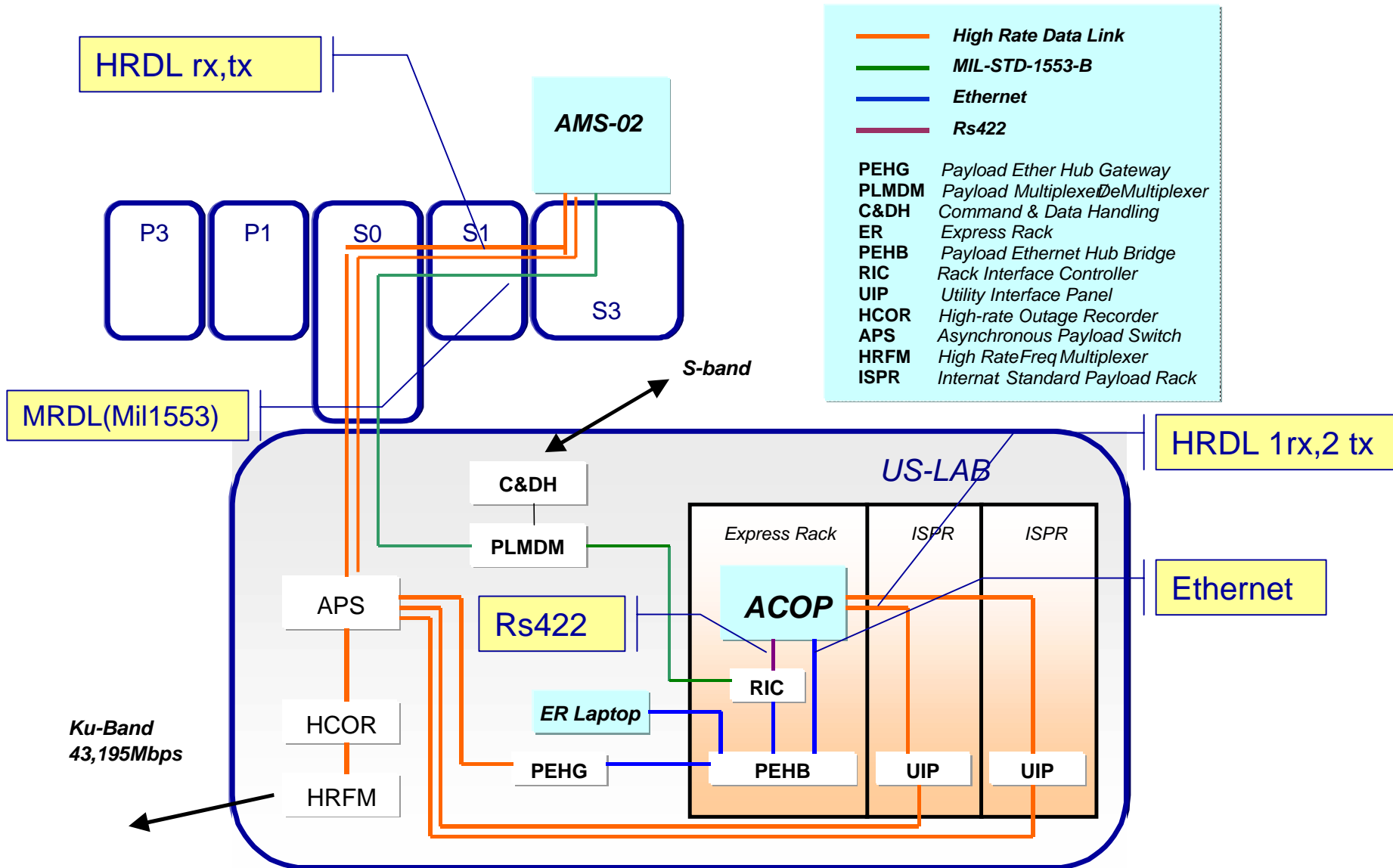
ACOP electrical architecture



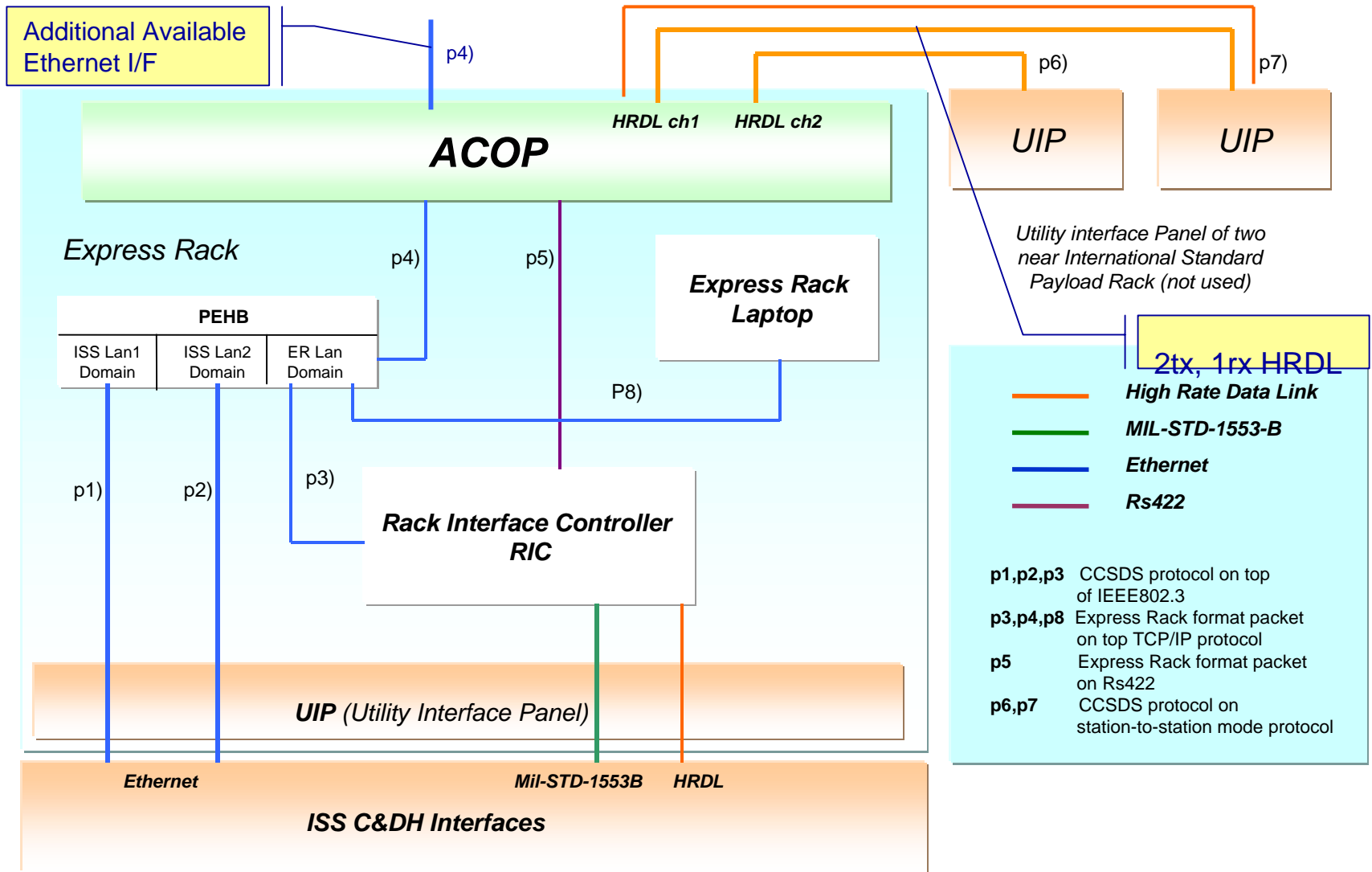
Command & Data Interface requirements

- The following Data Interface requirements will meet the SSP52000-IDD-ERP document section9.
 - Ethernet Interface. It will provide ER protocol to communicate to the RIC
 - Rs422 Interface.
- The HRDL Interface will meet the SSP52050 and SSP50183 document.

Command & data Handling: ISS Data I/F



Command & data Handling: ER Data I/F



Command & data Handling: RIC Data I/F

- RIC available data packets on Ethernet I/F. In the utilization column is defined the packets utilization in case of ACOP. The table is extracted from SSP52000-IDD-ERP

Description	Source	Destination	Frequency	Data Format	Utilization
Ethernet Payload to RIC					
Payload Health and Status	Payload	RIC	1Hz	Ethernet	Yes
PEP Bundle request	Payload	RIC	Async	Ethernet	No
PEP Procedure Execution Request	Payload	RIC	Async	Ethernet	No
Rack Time Request	Payload	RIC	Async	Ethernet	Yes
Ancillary Data Config Control	Payload	RIC	Async	Ethernet	Yes
Payload Telemetry Downlink Data	Payload	RIC	Async	Ethernet	Yes
EMU File Transfer Request	Payload	RIC	Async	Ethernet	No
Payload File Transfer Request	Payload	RIC	Async	Ethernet	Yes
Paylaod File Transfer Data Block	Payload	RIC	Async	Ethernet	No
RIC to Ethernet Payload					
Ancillary Data Set	RIC	Payload	Async, 0.1Hz, 1H	Ethernet	Yes
Broadcast Ancillary Data Packet	RIC	Payload	10Hz	Ethernet	Yes
Rack Request response	RIC	Payload	Async	Ethernet	Yes
Rack Time Response	RIC	Payload	Async	Ethernet	Yes
EMU File Transfer Request	RIC	Payload	Async	Ethernet	No
Payload File Transfer Request	RIC	Payload	Async	Ethernet	No
Paylaod File Transfer Data Block	RIC	Payload	Async	Ethernet	Yes
Routed PEP Commands	RIC	Payload	Async	Ethernet	Yes

C&D I/F's: HRDL Data packets

- On the Rs422 ACOP-RIC Interface are available the same data packets on Ethernet but for ACOP baseline the packets implementation is not foreseen.
- HRDL available data packets ACOP-AMS-02 (TBC)

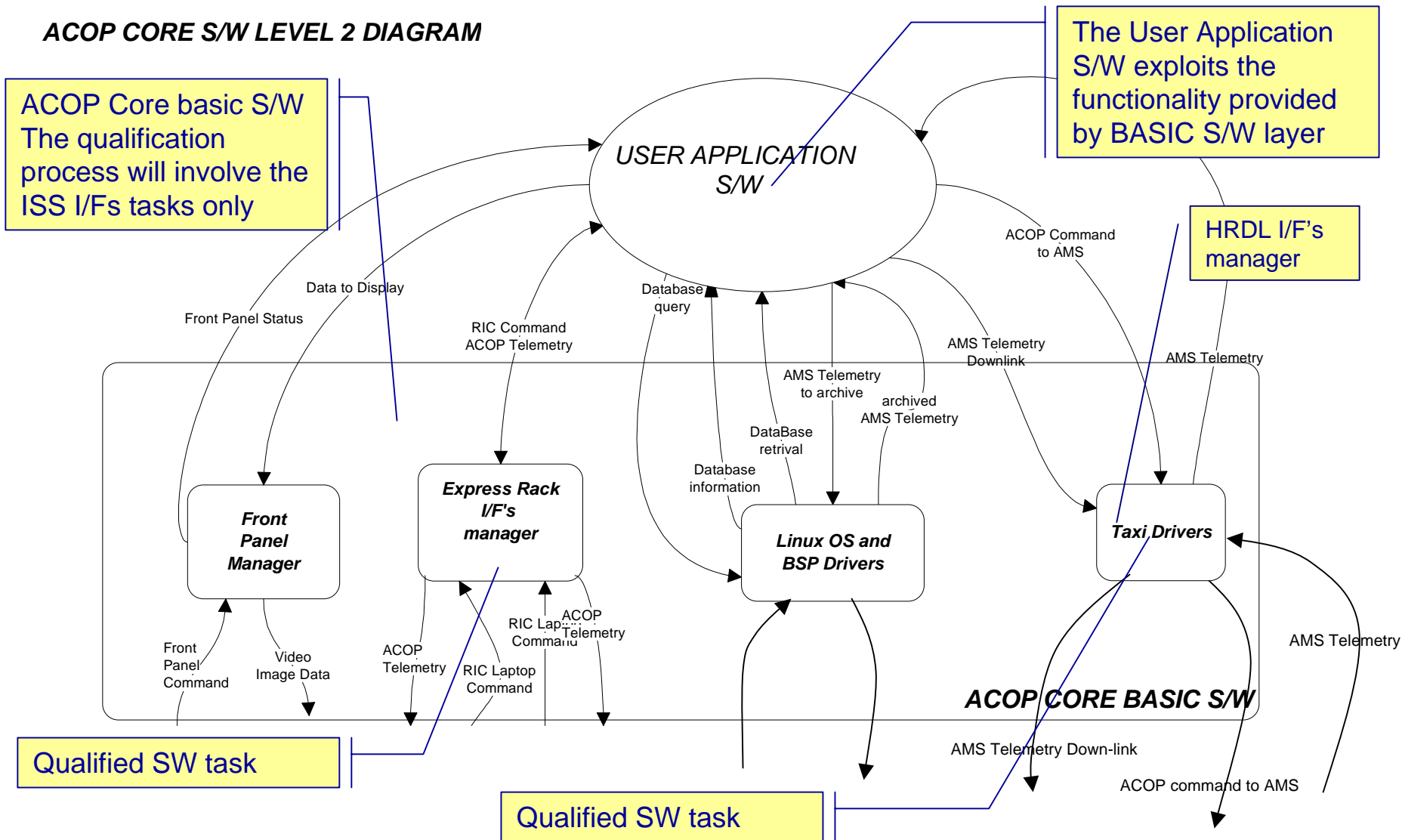
Description	Source	Destination	Frequency	Data Format	Utilization
ACOP to AMS-02					
ACOP Commands	ACOP	AMS	Async	HRDL	Yes
File Transfer Upload	ACOP	AMS	Async	HRDL	Yes
AMS-02 to ACOP					
Command Response	AMS	ACOP	Async	HRDL	Yes
AMS Health & Status	AMS	ACOP	Async	HRDL	Yes
AMS Scientific Data	AMS	ACOP	20Mbps (peak)	HRDL	Yes
AMS House Keeping	AMS	ACOP	Async	HRDL	Yes

SW Breakdown

- ACOP SW Breakdown
 - ACOP CORE S/W
 - ACOP CORE BASIC S/W
 - ACOP CORE USER APPLICATION S/W developed by MIT
 - ERLS (Express Rack Laptop Software) S/W
 - ERLS BASIC S/W
 - ERLS USER APPLICATION S/W developed by MIT

SW CORE Top Level Architecture

ACOP CORE S/W LEVEL 2 DIAGRAM



Human factor Interface

- The Human factor interface will meet the SSP52000-IDD-ERP document section 12.
- This requirement are applicable for the front panel and internal parts of ACOP to be replaced (ORU parts) or tool to be provided in order to replace the ORU parts.

Front Panel Design

